THE WIZARD STAFF MOBILE TOOL FOR HUMAN EXPLORATION ON THE LUNAR SURFACE.

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Introduction: The Wizard Staff is a rechargeable, battery powered mobile tool with multiple uses for lunar surface exploration. It supports human activity as a surface survey tool, provides external illumination to enhance safety, delivers networking, communications, and navigation functions to remote sites, and assists crew rescue with an emergency beacon and rigid splint structure.

Design: The staff integrates an upper and lower segment. The upper segment contains the LiDAR, external lighting arrays, cameras, communications equipment, intelligence devices, and user interface for crew operations. The lower segment contains $FeLiPO_4$ battery cells packed into the 5 cm (2") diameter carbon fiber tube. Discharged battery packs are easily replaced with a spring connector between the segments (designed for the dusty lunar environment). The lower segment can be used for Incapacitated Crew Rescue (ICR) as a rigid splint [1]. The functional staff weights 16 kg on Earth (2.7 kg on the Moon) and stands 2.1m tall, as shown in Figure 1:

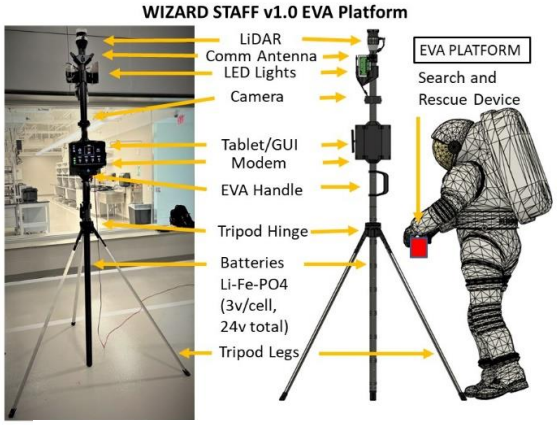


Figure 1: Wizard Staff V1.0 Prototype

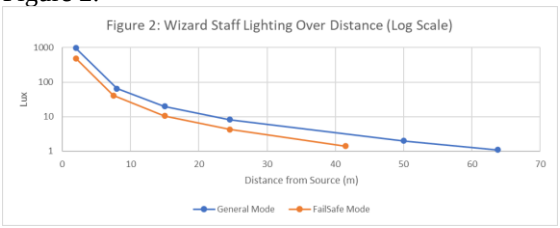
As a survey tool, the staff assists crewed geologic field site exploration with external lights, cameras, and LiDAR to illuminate, map, and record the sample collection process. As a relay station, it provides a surface intranet communications and navigation node for extended exploration far from the lander or habitation module. A separately developed Search-and-Rescue (SAR) handheld device can broadcast a signal to the Wizard Staff containing crew position and biometric data. The staff then formats the message and sends it orbiting satellite(s) for emergency response. The planned LunaNET uses a dedicated frequency similar to terrestrial applications for Emergency Position-Indicating Radiobeacon (EPIRB) devices.

As a stand-alone science platform, the Wizard Staff provides infrastructure for instruments and sensors to record the lunar environment over long periods of time. After a crew installs the components on the lunar surface, the platform delivers data to the lunar lander or base station for analysis. The stand-alone mode requires an auxiliary power source (e.g. solar array) and energy storage system (e.g. battery), so it could also be used as an electrical recharging station.

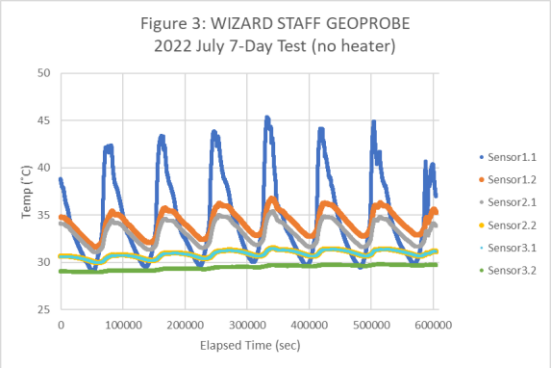
Development: A working prototype of an integrated Wizard Staff has been developed with collaboration between NASA (JSC, MSFC, and GSFC), Texas Space Technology Applications and Research (T STAR), and Texas A&M University (TAMU) [2]. Senior engineering Capstone students at Texas A&M University (TAMU) design, build, and test components of the Wizard Staff, and T STAR integrates each component into the overall staff. Grant funding is provided to T STAR, who provides the daily mentoring of the student teams. TAMU faculty guide the teams, and NASA Subject Matter Experts (SMEs) provide the technical requirements and insights during the development process.

Testing:

Lighting Lab: The initial lighting design included 4 computer boards each populated with 40 LED bulbs. Heat dissipation was provided with aluminum substrate on each card. Two tests of lighting components were completed at the JSC Lighting Lab with complete measurements of illumination, board temperature, and power draw on the staff battery system. The array produces 1000 Lux at 2m range (near field) and 2 Lux at 50m (far field) as shown in Figure 2:



Geothermal Probe: A geoprobe measuring temperature variation in the subsurface, with heaters to induce localized heating regions, was implemented following the Apollo Lunar Surface Experiments Package (ALSEP) design [3]. Connected to a separate solar array for and battery system, the Wizard Staff demonstrated capability as a stand-alone science platform measuring diurnal heat cycles in the College Station, Tx. summer of 2022 (see Figure 3).



Field Traverse: The integrated Wizard Staff was tested on a simulated EVA in both daylight and night operations using the full suite of instruments and sensors. Data from the staff was combined with standalone sensors (a heart-rate monitor, external video, and GPS receiver) to create an integrated display for assessment and analysis of the traverse. The Collaborative Operations Data Activation (CODA) tool [4] provides a Near Reat-Time (NRT) capability. The Wizard Staff demonstrated an Artemis era instrument design supporting NRT EVA playback, as shown I Figure 4:

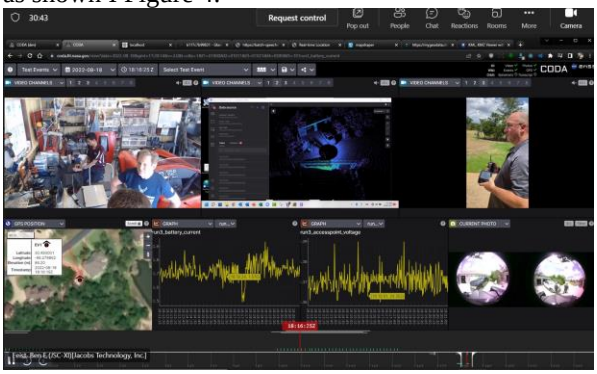


Figure 4: CODA Output from Wizard Staff Day EVA Test

Future Development: The Wizard Staff is working with the NASA Digital Transformation (DT) community to support digital advances in lunar exploration. Current plans are to update the initial staff prototype with new modem systems to support both mesh and 5G communications.

References: [1] Evans, M.E. et al (2021) *LPSC Abstract* #1303 [2] Evans, M.E. et al (2021) *AGU Fall Meeting Abstract #947284*, [3] Evans, M.E. et al (2022) *LPSC Abstract #2720*, [4] xxxxx, [4] Feist, B. (2022) https://coda.fit.nasa.gov